MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2019/2020

EME3046 - MECHANICS OF MATERIALS

(ME)

06 MARCH 2020
9.00 a.m.- 11.00 a.m.
(2 Hours, Open Book)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 6 pages with 5 Questions.
2. Questions 1 to 2 are **OPTIONAL**. Attempt only **ONE** out of the **TWO** questions.
3. Questions 3, 4 and 5 are **COMPULSORY**. You **MUST** attempt these questions.
4. All questions carry equal marks and the distribution of the marks for each question is given.
5. Write all your answers in the Answer Booklet provided.

OPTIONAL

Question 1:

The state of strain at a point on a plate is measured using the strain rosette shown in **Figure Q1**. Due to the loadings, the readings from the gauges give $\varepsilon_a = -60 \times 10^{-6}$ mm/mm, $\varepsilon_b = +350 \times 10^{-6}$ mm/mm, and $\varepsilon_c = +300 \times 10^{-6}$ mm/mm.

a) Provide the strain tensor.

[8 marks]

b) Determine the principal strains and corresponding directions (in degrees).

[6 marks]

c) Draw a complete strain Mohr diagram with labels. Show the given state of strain, principal strains and their orientations in the diagram.

[9 marks]

d) Is it possible for both plain stress and plain strain to occur concurrently? Explain.

[2 marks]

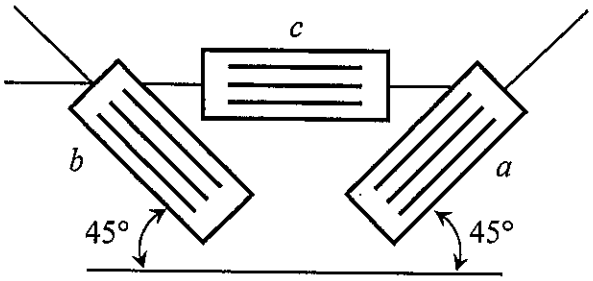

Figure Q1

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OPTIONAL

Question 2:

The distribution of stress in an isotropic aluminium machine component is given (in MPa) as:

$$\sigma_x = y + 2z^2 - 6 \qquad \tau_{xy} = 3z^2 - 11$$

$$\sigma_y = x + z - 6 \qquad \tau_{yz} = x^2 - 14$$

$$\sigma_z = 3x + y - 13 \qquad \tau_{xz} = y^2$$

x, y and z are coordinates of a point within the machine component. By taking Young's modulus, $E = 70$ GPa, Poisson ratio, $\nu = 0.3$ and yield stress, $Y = 5$ MPa, do the following for a point P located at (4, 1, 2):

a) Provide the stress and strain tensors.

[6 marks]

b) Determine all the principal stresses and principal strains.

[13 marks]

c) Determine if the machine component will fail based on the failure criteria below:

(i) Tresca criterion

(ii) Von Mises criterion

[6 marks]

Continued...

COMPULSORY

Question 3:

A beam is subjected to a midspan concentrated load P as shown in **Figure Q3**. Left end of the beam is fixed to a wall and the right end of the beam is supported by a roller. Select the reaction at the right end as the redundant. Let $EI = 1$ and do the following by using energy method:

a. Determine the magnitude of the reaction at the right end.

[11 marks]

b. Determine the deflection of the beam under the load P.

[11 marks]

c. If the support at the right end settles a vertical distance $-PL^3/32EI$, determine the magnitude of the reaction at the right end.

[3 marks]

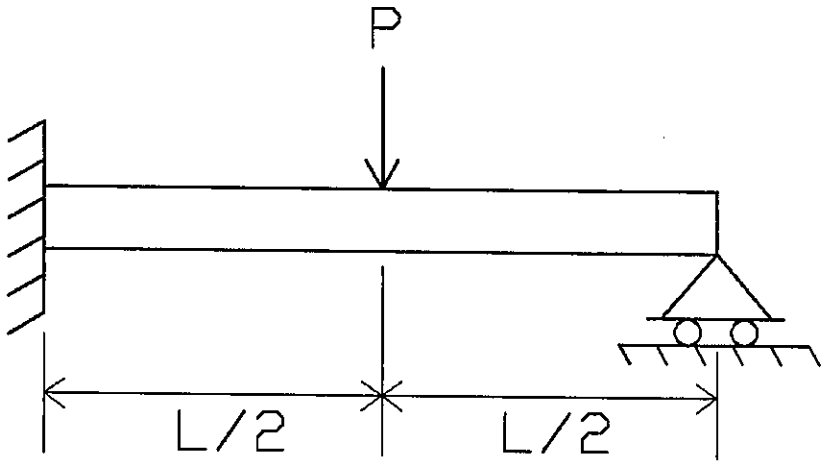


Figure Q3

Continued...

COMPULSORY

Question 4:

Cross section of an aluminium ($G = 27.1$ GPa) hollow thin-wall torsion member has the dimensions as shown in **Figure Q4**. Its length is 3 meters. $t1 = 5$ mm and $t2 = 4$ mm. If the member is subjected to a torque, $T = 11$ kNm, determine:

a. The shear flows (q_1 and q_2) and angle of twist.

[13 marks]

b. The shear stresses on each member (members 1 to 6)

[12 marks]

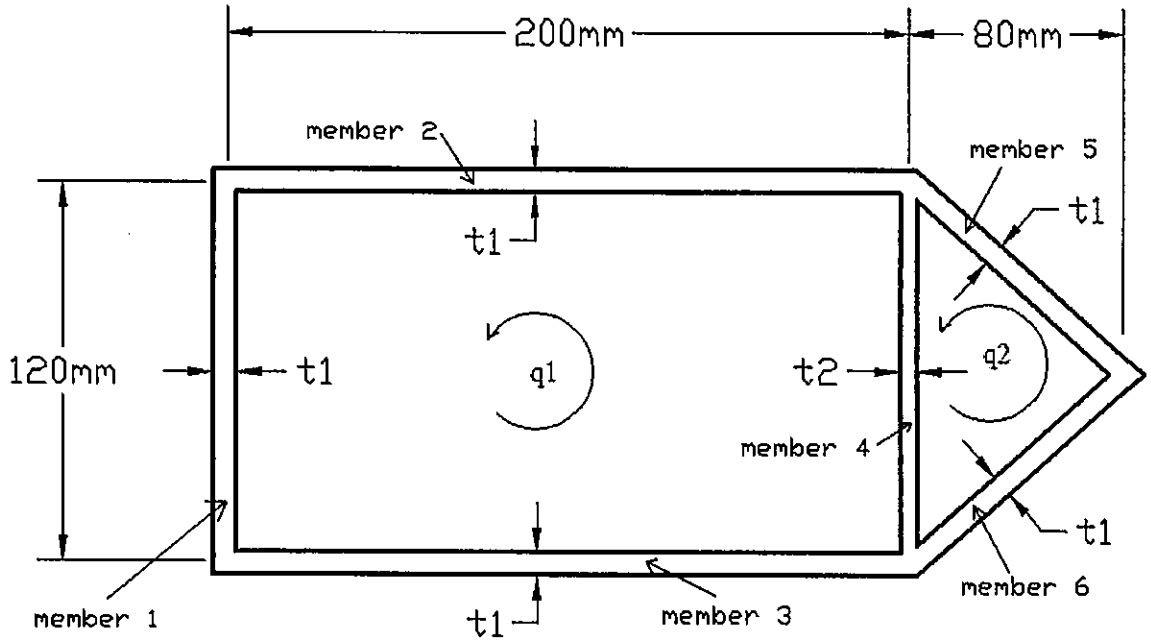


Figure Q4

Continued...

COMPULSORY

Question 5:

A hollow steel shaft (σ_y = 410 MPa, E = 200 GPa) as shown in **Figure Q5** is subjected to a force P = 10 kN.

a. Determine:
   i) the critical stress for the shaft for buckling (e = 0)

   [10 marks]

   ii) the maximum normal stress for the shaft when e = 150 mm.

   [6 marks]

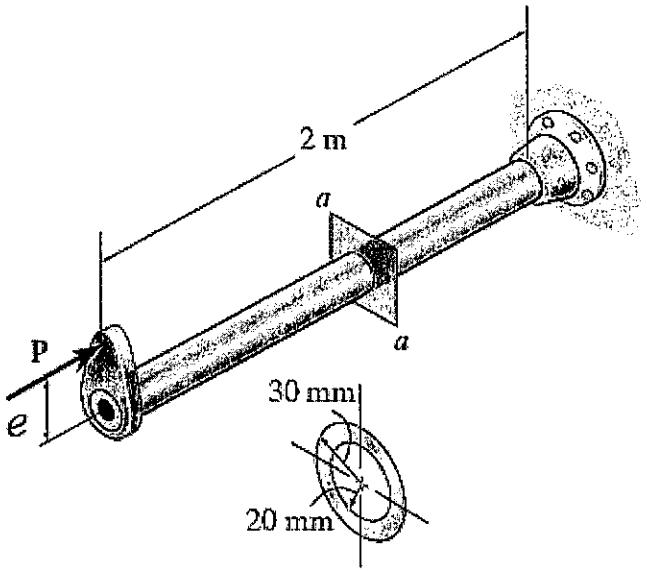
   Show that the formula/equations selected for the calculations are valid.

b. Determine the maximum deflection of the shaft when e = 150 mm.

   [3 marks]

c. Determine the maximum allowable dimension for e by considering factor of safety of 2.5.

   [6 marks]



Section $a-a$

Figure Q5

End of Paper.